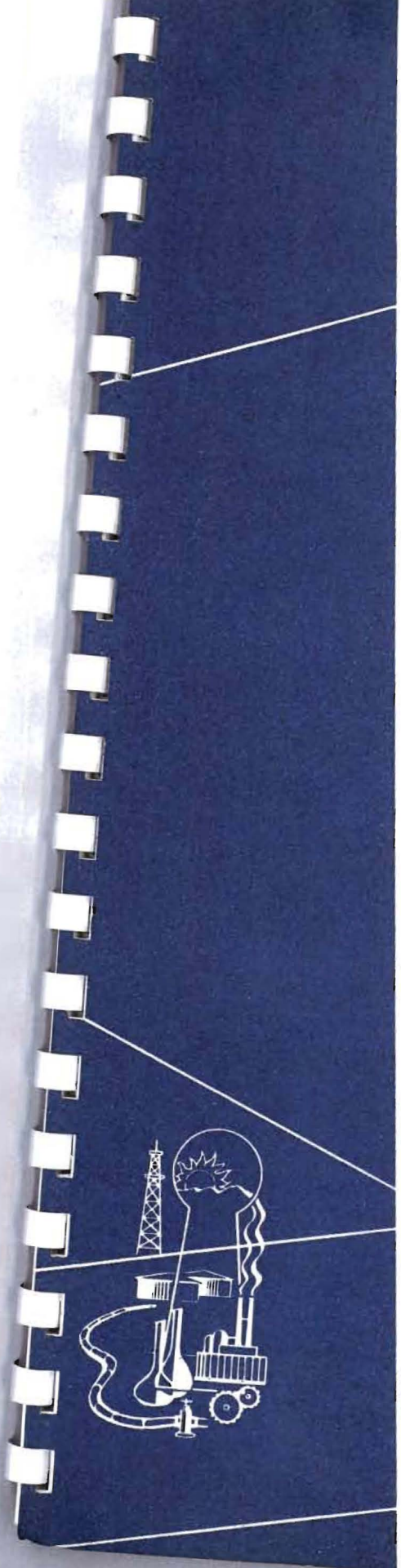

# PRESERVATION AND STORAGE OF SOUND RECORDINGS

M. M. Lemcoe

PROJECT NO. 721-2
PHASE I

DECEMBER 31, 1957

Department of Engineering Mechanics

S O U T H W E S T  R E S E A R C H  I N S T I T U T E
8500 Culebra Road, San Antonio 6, Texas

Department of Engineering Mechanics

# PRESERVATION AND STORAGE OF SOUND RECORDINGS

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PROJECT NO. 721-2
PHASE I

Prepared for

The Library of Congress
Washington, D. C.

Attn: Dr. Harold Spivacke
Chief, Music Division

December 31, 1957

APPROVED:

Edward Wenk, Jr., Chairman
Department of Engineering
Mechanics

ABSTRACT

The principal aim of the investigation is to develop suitable techniques for storing and preserving the records of the Music Division of the Library of Congress.

This progress report summarizes Phase I project activities and accomplishments to December 1, 1957.

Phase I of the project is primarily concerned with the determination of the parameters most responsible for record degradation via exploratory experimental studies conducted on an accelerated time scale.

The report includes (a) an outline of the accelerated chemical exposure tests, now in progress, and a description of the apparatus to conduct these tests, (b) a discussion of the techniques for studying record damage due to fungus, (c) a general description of the creep apparatus to be used, (d) a tentative list of the various types of records to be tested or used as standards, (e) a list of the play-back equipment to be procured for measurement of loss of fidelity after exposure of the records to prescribed histories, (f) a proposed questionnaire for circulation to the record industry to obtain vital information on record compositions, etc., (g) summaries of project conferences, and (h) a phase-wise breakdown for the entire project.

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# I. INTRODUCTION

It is the principal objective of the project to develop or recommend suitable techniques for the storage and preservation of pressed discs, instantaneous discs, and magnetic tapes, with particular attention focused on the record collection of the Music Division of the Library of Congress. To achieve this objective, a four phase program, as described in detail in Appendix A, will be carried out.

Initial work will be primarily concerned with studies relating to acetate and vinylite disc records. While a brief literature study is in progress on preservation problems associated with magnetic tapes, it is not proposed to divert project effort to tape until the studies on discs are well underway.

After completion of the "gross effects" study in Phase I, it should be possible to determine which of the environmental parameters are primarily responsible for loss in fidelity, embrittlement, increased susceptibility to wear, etc. Since mechanical wear per se is not considered within the scope of this project, except as it results from increased embrittlement, it is evident that an important aspect of the problem is that which relates to the physical and chemical changes due to aging under specific stress, temperature, humidity, and chemical environments.

Since fungus and dust damage to the surface have been definitely observed, another aspect of the problem will be that of developing or recommending practical ways of minimizing the damage from these sources. Here questions arise as to what type of jacket, if any, should be used, and, if so, of what kind of materia' it should be made.

Having determined from Phase I those parameters that are known to have a pronounced or definite deleterious effect on record fidelity or

life, a detailed study of only those parameters for which there will be a practical means of control, will be undertaken by rather precise measurements under closely controlled environmental conditions. It is hoped that it will be possible to predict, to some extent, the long-time aging effects as related to creep and embrittlement on the basis of short-time tests carried out under these closely controlled conditions.

This information should shed some light on how long existing records (of similar materials) may be expected to last on the shelves in the Library of Congress before they have to be re-recorded on another medium, due to acute groove fragility caused by embrittlement, loss of fidelity, etc.

Because of the time and budgetary considerations, it will not be possible to investigate records in all sizes and compositions. The investigation has, therefore, to be limited to magnetic tapes, acetate disc records, and only a few of the great myriad of compositions for the vinylite records.[1] Also, if it can be ascertained that the effect of record size is negligible, or that it can be accounted for with some degree of accuracy, it is not proposed to devote equal emphasis to all of the sizes (7, 10, 12, and 16 inches) which are to be tested.

At the conclusion of the study, a detailed final report will be submitted with specific recommendations as to what steps are considered necessary for proper storage and preservation of records, both in terms of the existing facilities and new facilities which may be required at a later date.

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[1] If shellac records are available, limited studies of them are also intended.

## II. WORK ACCOMPLISHMENTS AND PROJECT PLANNING DURING THE REPORT PERIOD

### A. Conferences

During the report period, several project conferences were held, including a conference of the Project Planning Committee at the Hotel Sheraton-Astor in New York on October 29, a conference at the Library of Congress on November 19 and 20, and a conference at Brown University on November 21, 1957.

Summaries of the important points covered during these conferences are contained in Appendices B, C, and D.

The information gained from these conferences has been most helpful in planning the detailed studies and experiments which are now getting underway.

### B. Fabrication of Exposure and Creep Testing Apparatus

Design and fabrication of a chemical exposure chamber is about complete. The chamber will accommodate up to six (6) records in 7, 10, 12, and 16 inch sizes, in addition to six (6) test strips. With this chamber, it will be possible to subject records to prescribed chemical environments, including those having high concentrations of oxygen and sulphur dioxide, under controlled temperature and humidity conditions.

Design and construction of the creep chamber for accurate measurements of creep, under stress in a closely controlled temperature and humidity atmosphere, is already underway. The design is such that it will be possible to conduct creep tests for several different loading configurations, including:

1. Discs horizontal and simply supported at center, with four downward concentrated loads applied 90° apart around the circumference of the records.

2. Discs horizontal and simply supported along two diametrically opposite points along the circumference, with two downward concentrated loads applied at points each 90° away from the supports.

As many as five records, each at a different stress level, can be simultaneously exposed to the same time-temperature-humidity history for the two above configurations.

3. Discs vertical and simply supported along bottom and restrained against horizontal displacement at the top edge, probably stressed under their own weight only.

The creep chamber itself consists of a double-walled aluminum cylinder, large enough to accommodate five 16-in. records, with specially ground plate glass windows through which measurements with an optical micrometer and other observations can be made. A special low-velocity circulation type heating system has been designed so that tests up to 175°F are possible with uniform temperature distribution throughout. During the brief period measurements are taken, the blower system is cut off. The humidity will be controlled by an external condensation apparatus to provide humidities from, essentially, 0 - 100% relative humidity.

C. Gross Effects Testing

The effects on aging of oxygen and sulphur dioxide are believed most important. Accelerated tests using them are in progress. An outline of these and other tests contemplated in Phase I follows:

1. Chemical Exposure Studies

a. Discs (blanks)

(1) Exposures in pure oxygen

(a) Low temperature, low humidity

(b) Low temperature, high humidity

(c) High temperature, low humidity

(d) High temperature, high humidity

(2) Exposures in high concentration of sulphur dioxide

(Same temperature-humidity conditions as 1.a.(1).)

b. Discs (with modulated grooves, Type 3, or conventional high fidelity music records, if Type 3 is not available when needed)

(Same exposures as 1.a.)

c. Strip specimens (smooth)

(Same exposures as 1.a.)

d. Strip specimens (with same modulated grooves as those in 1,b.)

(Same exposures as 1.a.)

The above tests will be conducted at room temperature or lower (low temperature), and at 150°F - 175°F (high temperature). Relative humidities will correspond roughly to 0% (low humidity) and 100% (high humidity).

The purpose of the exposure tests is to determine the long-time environmental effects on the mechanical properties of the record material on the basis of information gained from these short-time accelerated studies. The extent to which the environmental effects can be accelerated depends upon (a) the diffusion rate of the reactant oxygen or sulphur dioxide through the record surface, (b) the diffusion rate of the reactant within the record material to a randomly distributed reaction site, and (c) the rate of chemical reaction at the site itself.

It can be shown that, under the proposed test conditions, the chemical reaction rate (c) is much faster than the diffusion times (a) and (b), and, as a first approximation, it may be disregarded in calculating the total time for reaction. The rate of chemical change in the record material is therefore mainly a function of the diffusion rates. By using pure oxygen, instead of air, under the same conditions, it can be shown that the test is theoretically accelerated by a factor of approximately five. (Actually, however, the factor is much greater for a record in normal storage, since the stagnation of the atmosphere at the record surface keeps the oxygen concentration far below that of the normal atmospheric concentration.)

By changing the temperature, it is believed that an even greater acceleration in aging can be achieved, since the diffusion coefficient increases with increasing temperature. However, to verify this belief, tests will have to be conducted at various temperatures, since gas solubility decreases with increasing temperature.

By varying temperature and using pure oxygen, it is hoped to accelerate aging due to oxidation by a factor of approximately 500 to 1. Thus, a two week accelerated exposure would correspond to slightly less than 20 years on the shelf.

After the disc or strip specimens are exposed to the above histories, the changes due to these exposures will be measured.

2. Preliminary Creep Studies

   a. Discs (with modulated grooves from same lot and type used in 1.b.)

(1) Measurement of accelerated creep under known temperature, humidity, and exaggerated stress conditions

(a) Discs exposed to prior histories as in 1.a.

(b) Discs from same manufacturer's lot as in 2.a.(1)(a), but without the prior histories

b. Strip specimens (with same modulated grooves as those in 1.b.)

(Same histories as 2.a.)

(See Part II.B. for the different loading configurations which may be employed in conducting these creep tests.) The purpose of these studies is (a) to obtain long-time creep data from short-time tests, and (b) to induce prescribed distortions in the records, simulating effects due to storage in different positions, i.e. horizontal, vertical, etc, in varied environments.

3. Measurements of Loss of Fidelity and Increased Susceptibility to Mechanical Wear Due to Prior Histories in 1. and 2.

a. Discs (with modulated grooves as in 1.b.)

(1) Measurement of loss in fidelity after 1, 10, and 50 hours of play

(a) Discs exposed to same prior histories as in 1.a. and 2.a.(1)(a)

(b) Discs from same manufacturer's lot as in 2.a.(1)(a), but without the prior histories

The loss in fidelity will be measured with the precision play-back equipment described on page 13, and mechanical wear

in the grooves will be observed directly by means of a microscope. These measurements should therefore clearly show the effect of creep distortion in the grooves on fidelity, as well as the increased susceptibility to mechanical wear due to embrittlement and other chemical changes.

4. Embrittlement Tests

a. Strip specimens (smooth)

(1) These studies will consist of establishing an index for embrittlement in terms of the amount of bending curvature that can be sustained in the underside (tensile) of the specimen before a crack develops as a result of simple bending

(a) Strips exposed to same prior histories as 1.a.

(b) Strips from same manufacturer's lot as 2.a.(1)(a), but without the prior histories

b. Strip specimens (with same modulated grooves as those in 1.b.)

(Same histories as 4.a.(1).)

c. If time permits, other miscellaneous embrittlement tests will be conducted on discs in Phase I to determine possible embrittlement caused by loss of plasticizer due to rubbing and "wicking" actions. Otherwise, these tests will be conducted in Phase II.

5. Fungus Studies

A study of fungus attack on records is now in progress. Of the sample records taken from the stacks and forwarded

to Southwest Research Institute, two (No. 4 and No. 6) show definite signs of fungus attack. Evidence of fungus growth on the jackets was also observed. It is also believed that parallel lines, extending across the record which the writer took with him after his visit to the Library of Congress, are a result of fungus attack.

Before further fungus studies can be undertaken, approximately eight to ten 10 or 12-in. records, taken from the stacks, showing evidence of fungus, will be required. These records must have been stored in the stacks in their jackets and undisturbed for at least six to eight months. The position of the paper jacket with respect to the records should not be altered. In "hunting" through the stacks for records which meet these requirements, it will be necessary to carefully slit the paper jacket along two opposite edges and carefully lift the top to determine if fungus is present, without altering the position of the jacket with respect to the record. It is then suggested that register or match marks in crayon be placed on both the jacket and record at two locations, so that it will be easy to "re-match" the relative position of jacket and record. A close inspection of one of the shellac records, of the samples on hand, shows presence of fungus on both the record and the jacket. It thus appears that the fungi feed on the paper jacket and excrete material which attacks the record, since it was noted that the patterns on the jacket matched the fungus patterns on the record.

The following aspects of the fungus problem will therefore have to be considered in more detail:

1. Whether the types of fungi which feed on paper record jackets (grow on the jacket) can also etch "modern" records made of acetate or vinylite as well as shellac records.
2. Whether the types of fungi which feed on the plasticizer (grow on the record) also secrete chemicals capable of etching the records.
3. Whether significant embrittlement results from loss of plasticizer due to fungi consumption of it.

The following study of approximately one month duration is proposed:

a. Identification of fungi, from scrapings taken from the jacket.
b. Identification of fungi or spores, from scrapings or brushings taken from the record.
c. Correlation of fungus growth on paper jacket with fungus growth, etching, or other damage on the record.
d. On the Library of Congress records, provided for the fungus studies and already showing damage, artificially induce fungus growth in new locations to determine if same type of etching damage occurs, using same scrapings or brushings from a. or b., after appropriate culturing, etc.
e. Repeat same experiment in d. with new vinylite and acetate records to determine if they are equally susceptible to fungus attack.

From the above studies, it should be possible to determine what the best storage procedures are, and what type of jacket, if any, should be used, to minimize fungus or spore damage.

6. Preparation of a Questionnaire

In order to obtain reliable information and answers to many pressing questions confronting the project staff, regarding details of record manufacture, record compositions, etc., within the minimum time possible, a tentative questionnaire to be circulated to the record industry by the Library of Congress has been prepared. A sample of this questionnaire may be found in Appendix E.

It is hoped that from the information gained from this survey, it will be possible to narrow down the number of different types of vinylite compositions to be tested to only a few, without loss in generality of conclusions reached. Fortunately, the vinyl powder used in manufacture of vinylite records by a good portion of the industry comes from the same source, and since, percentagewise, it represents by far the predominating constituent, it is therefore felt that it may be possible to limit the studies to only a few compositions.

7. Determination of the Types and Number of Records to be Procured by the Library of Congress

During and subsequent to the writer's referenced visit to the Library of Congress, a detailed list of the various types of acetate and vinylite test records was developed. This list appears in Appendix F. This list has been circulated to various members of the project staff from the

Chemistry and Chemical Engineering Department, the Electrical Engineering Department, and the Engineering Mechanics Department, and was considered acceptable. There is a fair possibility that all the records ordered will not be tested, particularly in the 7 and 10-in. sizes, if it can be demonstrated that there is little difference in performance between them and the other sizes tested. However, this remains to be seen, and in the interests of time and the minimum size orders which record manufacturers will accept, it is felt that this list should be considered final, and that the vinylite records be ordered as quickly as possible. However, there are two items which should first be considered:

1. The pressing operations should include whatever records Dr. Prager wishes to have made for possible photoelastic or other studies.
2. The different types of compounds used for the vinylite test records should be representative of the range in properties that can be expected from the industry at large. While the five compounds mentioned in Mr. Wegner's letter to Dr. Spivacke, dated August 1, 1957, may meet this requirement, it may not be possible to establish this fact with certainty, until the results of the questionnaire are tabulated. Undoubtedly, personal visits or contacts with key record materials suppliers or record manufacturers would expedite getting this information.

8. Selection of Playback Equipment for Measurement of Loss of Fidelity

The following is a list of the playback equipment, which is being procured for measurement of loss of fidelity after exposure of records to various histories:

a. Rek-O-Kut, B16H, 16" turntable

b. Rek-O-Kut console for a.

c. Rek-O-Kut A-160, 16" arm

d. Pickering 371-D pickup, with single LP stylus, plus additional D-3427, 78 rpm stylus assembly

e. Pickering 132 E equalizer

The Cinema Engineering Company Equalizer 7087 was considered. However, this unit has a 500-600 ohm input and output impedance with 20 db insertion loss, and equalizes only to the R.I.A.A. curve. For these reasons, the Pickering 132E equalizer was selected instead. The Presto Model 10-B turntable was also considered. However, it has been found that this model has been discontinued, and for this reason the Rek-O-Kut turntable was selected, along with the matching console cabinet and arm.

## III. FISCAL AND CONTRACTUAL MATTERS

Project expenditures to December 1, 1957, total approximately $3780, not including the playback equipment which is now being procured.

According to the time schedule in Appendix A, it was originally estimated that Phase I would be completed within three (3) months, after commencement of the project, or about January 1, 1958. However, in view of the fact that commencement of detailed laboratory work was not feasible until after technical conferences with Dr. Spivacke, Mr. Carneal, Dr. Prager, and his associates, during the third week in November, and the fact that no vinylite test records are on hand, it will not be possible to complete Phase I by January 1. Assuming receipt of the vinylite records within three to four weeks, it is now estimated that Phase I should be completed by the end of March 1958. In any event, every effort will be made to move ahead as swiftly as possible, by careful scheduling of the tests and other phases of the work.

# APPENDIXES

APPENDIX A

PROGRAM BREAK-DOWN

Phase I Duration, 3 months
Estimated cost, approximately $10,000

a) From a list of all deleterious effects which can be stated without detailed study, review and evaluate all items, and eliminate those believed to be of little significance.

b) For those remaining, design and conduct a number of very crude exploratory tests in which the conditions are so exaggerated as to accelerate degradation.

Such tests would explore creep at elevated temperatures, effects of oxidation, etc., so as to determine from purely exploratory sallies whether one effect is more pronounced than others.

c) Determine loss in fidelity and volume due to wear so that items in part b) could be evaluated in terms of both loss in fidelity and effects of repeated playing.

d) Anticipate possible solutions such as thin metallic films and study feasibility.

Phase II Duration, 6 months
Estimated cost, $25,000

a) Conduct experiments under controlled conditions to investigate those items which were found from Phase I to warrant detailed study.

b) Introduce results from earlier feasibility studies; that is, study only those items which from considerations of feasibility tests would appear practicable as solutions to degradation.

Phase III Duration, 3 months
Estimated cost, $10,000

a) Recapitulate results from Phase II and determine whether program is in need of re-orientation.

b) Determine which additional tests, if any, are necessary.

c) Develop in more detail mechanical and chemical means of counteracting causes of degradation from earlier studies.

Phase IV Duration, 2 months
Estimated cost, $5000

Complete final reports on project.

APPENDIX B

Minutes of October 29, 1957, Meeting of Project Planning Committee
for Library of Congress Project, SwRI 721-2
"Preservation and Storage of Audio Transcriptions"

1. The meeting held at the Hotel Sheraton - Astor, New York City, was attended by:

| | |
|---|---|
| Dr. Harold Spivacke | Library of Congress, Chairman |
| Prof. William Prager | Providence, Consultant |
| Mr. Martin Goland | SwRI |
| Dr. Edward Wenk, Jr. | SwRI |

2. Inasmuch as this was the initial session of the Project Planning Committee, the agenda was directed to an expanded statement and discussion of project objectives, an examination of the SwRI proposed framework of action to implement the program, arrangements for co-operation and identification of areas where technical assistance from Professor Prager would be most effective, and an identification of test recordings, materials, and information to be developed or provided by the Library of Congress for use on the project. Background information referred to at the meeting is set forth in the October 21, 1957, minutes of SwRI staff meeting, and attachments thereto.

3. Early in discussions, it became evident that two different approaches to the project were possible, each with attractive features, but just as important, each with significant objections and shortcomings. In both programs, the ultimate objective was the optimum record storage. However, the first procedure would be strongly oriented toward the detailed study of record degradation; that is, the investigation by various means of what causes deterioration and the rates of different types of deterioration under various conditions of "uncared for" storage. It was agreed that such a study was possible, but could involve many years and considerable funds in data collection, because so many factors were involved. An

alternate approach would involve only preliminary studies of various degrading influences from available knowledge in the field and from rough exploratory tests, after which only those factors of greatest significance would be further investigated, and these only to determine the qualitative effect, and appropriate prophylactic measures to reduce deterioration, rather than detailed studies of cause-and-effect, with quantitative data. After exploring the relative merits of these two different approaches, it was decided to adopt a compromise between the two. In other words, the causes of record degradation would be examined only for purposes of identifying the most important factors and of advising the sponsor on the probable life span of various types of records, after which, as part of the project, attention would be directed to methods of storage to minimize degradation and thus to prolong life and fidelity.

4. It was agreed to adopt attachment IV of the SwRI project staff minutes as a framework of action to implement the program with the objectives restated according to paragraph 3 preceding and with a redefinition of Ic limiting studies of wear due to repeated playings.

5. Dr. Spivacke noted that record storage systems should be practicable; that is, shelf availability must be maintained. This would prohibit such contraptions as hermetically sealed cans. Polyethylene wrappers are possibilities, although cellophane has been reported to be objectionable.

6. Professor Prager agreed to supplement SwRI studies (a) by recommending types and means of interpretation of accelerated tests to simulate effects of long term warp and creep in various stress fields associated with vertical or horizontal, edge and/or spindle storage, and (b) by conducting theoretical plasticity analyses corresponding to these various storage attitudes.

7. The matter of record wear and stylus improvement was noted by Dr. Spivacke as a subject for a subsequent project, except as it must be considered as related here to degrading embrittlement.

8. Dr. Spivacke also added the following details which should be considered by the project staff:

   a. Any questionnaire to be sent to manufacturers should immediately be prepared by SwRI and forwarded to Dr. Spivacke for Library of Congress circulation.

   b. No study will be made of sound tracks on photographic (movie) film. Deterioration of film has already been studied by Archives, under Carnegie grant. Steel base acetate will also not be studied, but glass base acetate should be.

   c. Records are not circulated outside of Library of Congress.

   d. Quality of speech records should be preserved with as much fidelity as music records. The whole question of quality is relative. It may be more important to preserve an acoustically poor old record than a hi-fi new one. The purpose of the project is to learn to save as much as is still possible to save.

   e. If there is to be a question of relative emphasis, it should be placed on modern plastic and magnetic tape records, rather than shellac which cannot be eliminated but are still not as vital as the LP's.

   f. From discussions with manufacturers, the variety of formulations in both old and new records did not seem as great as originally believed.

9. On the matter of test recordings, the types suggested on page 4 of attachment III were generally concurred with, except that provision should be made for variation in groove size. SwRI is to "order" the first set of test recordings by Nov. 5, taking into consideration that:

a. Library of Congress can cut "acetate" blanks.

b. Modern plastic blanks can be pressed by various companies on order from Library of Congress.

c. Facilities for pressing shellac records may no longer exist but will be investigated by Library of Congress; recutting existing shellac discs is not feasible.

10. Prof. Prager will consider some photoelastic tests to study residual stresses introduced by pressing. Models to be of contemporary materials, free of coloring matter, and pressed at same time as blanks ordered according to paragraph 9-b.

11. Since grant from Rockefeller is on a fiscal year basis, arrangements for consulting by Prof. Prager will be initially established "as advisor to SwRI" for interval ending June 30, 1958, and then renewed. Fee to be $300 per month, with Prof. Prager making arrangements himself for any additional assistance by colleagues. If satisfactory to Mr. Hulen of SwRI, SwRI will write one intrument to provide for Prof. Prager's assistance, thus avoiding monthly invoices.

12. SwRI is to provide Prof. Prager with copies of proposal to Library of Congress, without fiscal information, and of October 21 SwRI minutes.

13. Dr. Spivacke is to provide SwRI with photostats of USNUSL, RCA, and other reports on permanence of tape recordings. He will also forward his comments on details given in SwRI's October 21st minutes.

14. It was agreed that Dr. M. M. Lemcoe, SwRI project leader, should visit Library of Congress and Prof. Prager at an early date.

15. The next meeting of the Project Planning Committee was set for San Antonio, probably late in December or early in January.

Respectfully submitted,

Edward Wenk, Jr.
Recorder

EW:mml

APPENDIX C

TRIP REPORT

Library of Congress
Washington, D. C.

Dr. Harold Spivacke, Chief, Music Division

Mr. Robert B. Carneal, Chief Engineer, Recording Laboratory

Purpose of Visit: Project Long-Fi

The following is a summary of data and information obtained during subject visit on November 19 and 20, 1957:

1. Pertinent Details on Record Storage and Environment

The stacks in which the records are stored extend above and below street level, separated by a slotted floor to permit air circulation. In the winter, heat is provided by feeding hot water into a heating coil system within which is a water spray--the outside air being drawn in past these coils by means of two 48-in. fans which in turn force the air into the bottom of the stack area, one floor below the street level. A similar fan in the attic acts as an exhaust fan. When the temperature in the stack area registers below 75°F, hot water is circulated through the coils. When the stack temperature reaches 84°F, the hot water circulation is cut off, leaving the fan blowing. It is understood that the temperature in the stacks is fairly constant from September through April, using this arrangement.

In the summer, there is no artificial cooling at all and the outside air is brought in, as is, 24 hours a day through the same fans. It is also understood that a 20°F temperature change during a 24-hour period is not uncommon. Temperature readings taken in the Northeast book stacks, commencing January of this year, show the highest temperature to occur in July and August, with readings as high as approximately 92°F.

Analysis of past records show that relative humidity in Washington averages out between 50 and 75%, so that high humidities in the stacks may also be expected. The humidity of the air in the stacks is estimated to be within 2% of the outside humidity.

Aside from the stacks proper, records are also stored in the Annex, which is air-conditioned. Tapes are stored in an air-conditioned room in the main building.

The disc records are stored in various ways. Some are stored vertically, some horizontally, some "off the vertical," some in metal containers, some in pasteboard containers, some in wooden boxes, and some in paper or plastic jackets. While every effort is made to preserve the records, consistent with the available staff and funds, much remains to be desired in controlling the dust and properly stacking the records. There were definite signs of fungus attack, as well as abrasive scratches of the records due to dust.

Discs are cleaned by blowing air on them, only.

2. Inventory and Operational Information

Detailed information concerning an inventory of the various types of records was not available. However, the following figures provide a rough breakdown of material on hand:

| | | |
|---|---|---|
| a. | Shellac Records | 50,000-75,000 |
| b. | Vinylite Records | 25,000 |
| c. | Acetate Records | 250,000 |
| d. | Tapes | 2,000 |

The accession rate of the vinylite records has varied over rather broad limits. An average figure of 6000 per year was suggested. This figure is expected to grow substantially. While it is envisioned that playback booths will be installed at some future date, for public use, there is virtually nothing available for public use at this time. In any event, records are not loaned out, except under very unusual circumstances. They do sell folk-music records which are made under the direction of the Music Division, but this has nothing to do with our project. Until more funds and staff are available, problems regarding mechanical wear, adjustment, and alignment of playback equipment, circulation procedures, handling procedures, etc., are of no consequence, although they might serve as a basis for further work at a later date.

3. Clarification of Certain Points

a. On Life and Degradation Criteria

It was felt that there is no practical procedure for establishing limits as to life in terms of years of preservation, or degradation of fidelity. Dr. Spivacke would like to preserve as much of what is already on the record for as long as possible, regardless of record type or category.

b. Storage of Records in Cylinders or other Contraptions

It was agreed that it might be necessary, for certain "precious" records, which are played only very infrequently, to preserve such records in cylinders containing an inert gas.

c. Air Conditioning

There should be no hesitation in recommending air conditioning of the stacks, if this should appear necessary, even though there are no provisions for air conditioning the main stacks at present.

4. Preparation and Procurement of Test Records

Bob Carneal and the writer drafted up a tentative list of the various types and sizes of both acetate and vinylite records which would be cut by his staff or procured from record manufacturers. It was recognized early in the discussion that it would be impossible to predict how many of each type of record should be procured. It was decided that the estimate should be generous, rather than risk the possibility of running out of test records. This list will be circulated to the various project staff for their approval prior to finalizing the list, and returned to Dr. Spivacke and Bob Carneal, who will handle procurement of the records.

It was learned that their recording equipment to cut the standard frequency test discs is not satisfactory above 9000 c.p.s. They propose to have these test records cut at the Voice of America recording laboratory. Even so, the upper frequency will be limited to 15,000 c.p.s. Carneal doubts very much the possibility of achieving the 18,000 c.p.s. which we originally requested.

5. Recommended Playback Equipment

I mentioned to Carneal that we would have to purchase certain playback equipment and showed him the list proposed by our Electrical Engineering Department. On the whole, he thought our selection was quite good, but made a few suggestions. These suggestions have already been forwarded to John Prucha for his comments.

6. Items or Information Which Will Be Sent to Us in the Near Future

a. Six (6) sample records depicting various types of defects found in Library of Congress records. (These have been received).

b. Blank acetate discs in 12 and 16-in. size. (These have been received).

c. Forty (40) precut unmodulated groove records (See Attachment No. 1, Type 2 records). (Carneal said he would try to ship them by December 8, if possible)

d. Standard Frequency test discs, Type 3. (Carneal will endeavor to cut them shortly after the Christmas Holidays).

e. A portion or all of the Type 3X records. (We might receive these by the third week in February).

f. A portion or all of the Type 4 records. (We might receive these by the first week in March).

g. A portion or all of the Type 5 records. (We might receive these by the third week in March).

h. List of the characteristics of the Sponsor's recording equipment. (We might receive this by the first week in January).

i. Temperature and humidity data, preferably in the stacks, going back at least ten (10) years. (A good portion of this data has already been received.)

j. A gas analysis of the air in Washington, D. C. (This information is now being developed by the District of Columbia Department of Public Health.)

In terms of the information gained during this visit, it does not appear that there are sufficient data regarding such items as: number of records on hand, size, age, type (music, speech, etc.), number of times checked out, replaceability, accession rate, distribution, circulation, acceptable limits of degradation, specified life, etc., as to make an Operations Research type of analysis feasible.

In parting, I told Dr. Spivacke we would get started on gross effects testing as soon as record material was received.

M. M. Lemcoe

M. M. Lemcoe

MML/bb

APPENDIX D

TRIP REPORT

Brown University
Providence 12, Rhode Island

Dr. William Prager
Dr. D. C. Drucker
Dr. Wm. N. Findley
Dr. E. H. Lee
Dr. Harry Kolsky
Dr. Eli Sternberg

Purpose of Visit: Project Long-Fi

I visited Dr. Prager et al on November 21, 1957. Dr. Prager and his associates were briefed on my visit to the Library of Congress and other project activities which might be of significance to them as our consultants.

It is their opinion that no detailed theoretical study of record creep or warpage should be made until it is ascertained whether the mechanism involved is primarily mechanical or chemical in nature. Also, before formulating any analytical relations for prediction of long-time effects from short-time accelerated tests, it was agreed by all that the applicability of superposition principles must first be looked into. Various types of approaches to help answer these questions were discussed, including the application of differential atmospheric environment from one side of the record to the other side. Thus, if up warping of a record were in a direction opposite to the gravity forces, while in this environment, it may be assumed that the action is primarily chemical in nature. Experimentally, it will be possible to check on the applicability of superposition with our "creep chamber", which will permit obtaining the stress-deformation-time characteristics for five disc-type specimens, exposed simultaneously to the same temperature-humidity environment.

With respect to storage of records, Dr. Prager suggested that the creep of records, when stored vertically, might be checked by running two parallel experiments:

1. Record vertical with no side plates, under action of the gravity forces only.

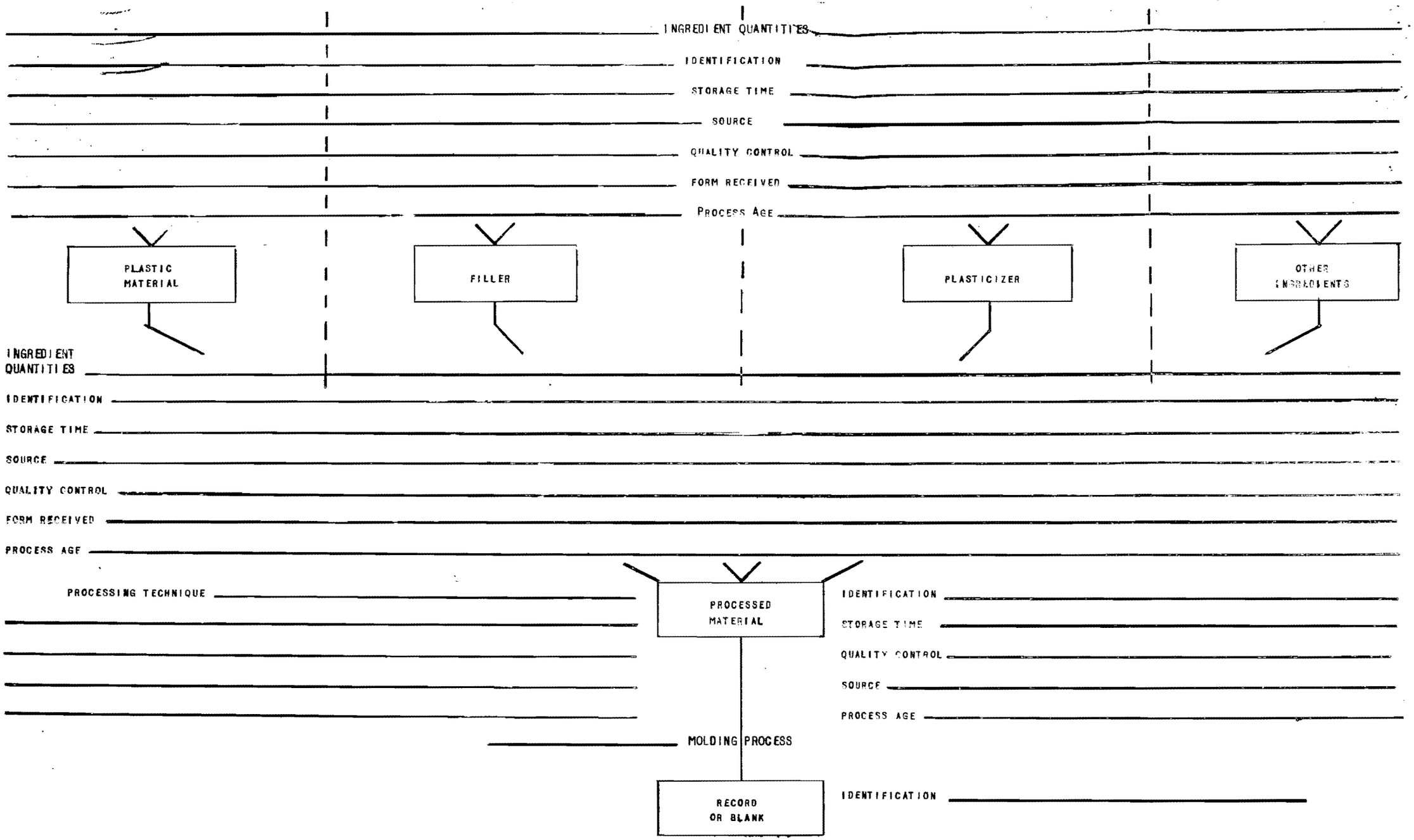
2. Record vertical with side plates which would provide a more or less uniform pressure to the record.

The component of friction in the vertical direction from the side plates would thus tend to minimize the creep due to the downward gravity component of force. If significant reduction of creep resulted, the feasibility of using a hinged type jacket for the vertical record storage might be further explored. In any event, it would appear that by conducting these experiments and comparing results with records stored horizontally, the pros and cons of whether records should be stored vertically or horizontally might be further clarified.

To investigate the extent of creep when records are stacked horizontally, it was felt that this could be done by introducing small spacers which would simulate record unevenness. The resulting creep could then be studied in the creep chamber.

APPENDIX E

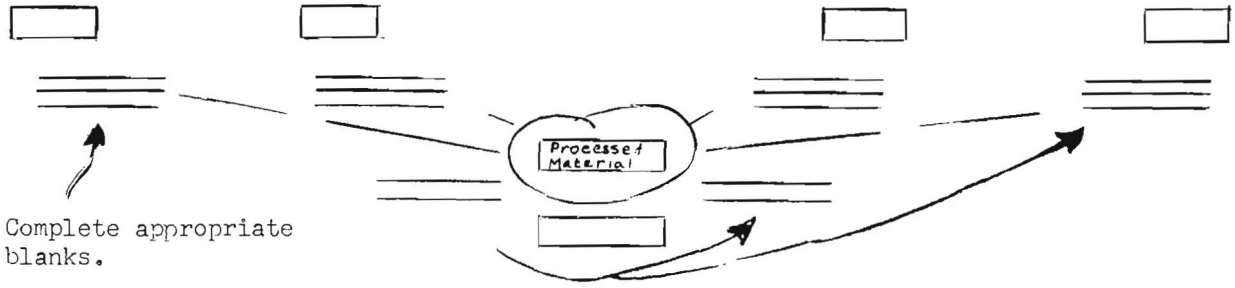
## QUESTIONNAIRE TO MANUFACTURERS OF RECORD AND RECORDING MATERIALS FOR ANALYSIS OF PARAMETERS WHICH AFFECT STORAGE LIFE




REMARKS: (IF ADDITIONAL SPACE IS REQUIRED, PLEASE USE REVERSE SIDE.)

INSTRUCTIONS:

1. In order to complete this questionnaire, first circle the portion of the process which is done by your organization; (for example, if you obtain ingredients from others and make the processed material to sell to others who mold the records, circle "Processed Material" only). Then, fill in the blanks involved in your portion of the process as indicated below.




Complete appropriate blanks.

2. Please complete a blank for each different record material you use or produce and for each material you have formerly used.

GLOSSARY OR DESCRIPTION OF TERMS USED IN QUESTIONNAIRE:

Ingredient quantities - the amounts of each ingredient used in compounding a batch of your product (%, #, gals., etc.).

Identification - trade or chemical name of ingredient.

Storage time - the maximum length of time the material may be stored before use.

Source - producer or jobber from whom you obtain the ingredient or product.

Quality control - specifications or tests required to accept or reject an ingredient or product.

Form received - form in which ingredient is received (powder, grains, sheets, fluid, etc.).

Process age - length of time you have used this process.

Processing technique - a brief description (such as mix dry, heat and form into sheets).

APPENDIX F

## LIST OF TYPES OF RECORDS TO BE PROCURED
## PHASE I ACETATE

Type 1. Thirty (30) blank discs.
15 - 12" double faced regulars.
15 - 16" double faced regulars.
Master discs are picked 12" double faced regulars, and are picked for smoothness of coating.

Type 2. Thirty-five (35) records, precut on both sides with unmodulated grooves at various groove pitch.
15 - 12" discs at 78 rpm cut at 88, 104, 112, and 120 lines per inch.
15 - 16" discs at 33-1/3 rpm cut at 88, 104, 112, and 120 lines per inch.
5 - 12" master discs at 33-1/3 rpm microgroove cut at 247, 270, and 300 lines per inch.
Master discs are available only in single face discs, all others to be cut both sides identical.

Type 3. Forty (40) standard frequency test discs with bands recorded at fixed frequencies from the outside of 10kc, 9kc, 8kc, 7kc, 6kc, 5kc, 4kc, 3kc, 2kc, 1kc, spiral, 1kc, 2kc, 3kc, 4kc, 5kc, 6kc, 7kc, 8kc, 9kc, 10kc, and 1kc. Each frequency to be 5 seconds long with a 10 second pause between frequencies. Discs to be recorded at constant velocity on one side and NAB equalization on the reverse.

10 - 12" 78 rpm cut at 104 lines per inch.
10 - 12" 33-1/3 rpm cut at 128 lines per inch.
10 - 16" 33-1/3 rpm cut at 128 lines per inch.
10 - 12" 33-1/3 rpm microgroove cut at 240 lines per inch.

Due to the short length of the 78 rpm records the frequencies will descend from 10kc to 1kc only and will not continue back up the frequency scale. The pause between bands will be cut to 15 seconds. The microgroove records will be single faced only with both the constant velocity and NAB cuts on the same side. The 16" discs will have a third frequency run on each side to bring the recorded signal into the inner diameters. Data sheets will be sent with each record giving complete information in reference to the material recorded.

Type 3X. Forty (40) discs for constant amplitude recording; these discs with bands recorded at fixed frequencies of 50cps, 100cps, 200cps, 300cps, 400cps, spiral, 400cps, 300cps, 200cps, 100cps, 50cps. There will be a voice announcement of frequency past and level indicated by VU meter across the recording head. Each frequency will have a minimum level, intermediate level and highest practical level included in each frequency band.
10 - 12" 78 rpm cut at 96 lines per inch.
10 - 12" 33-1/3 rpm cut at 96 lines per inch.
10 - 16" 33 1/3 rpm microgroove cut at 247 lines per inch.
The microgroove records will be single faced only.

Type 4. Forty (40) Sweep frequency test records varying from 50 cycles to 10 kcs. with NAB equalization to permit evaluation of cross-talk. One side to be recorded at standard reference level (Zero DBM at 1000 cps.) and the reverse side to be recorded 10 DBM above this level.
10 - 12" 78 rpm cut at 96 lines per inch.
10 - 12" 33-1/3 rpm cut at 96 lines per inch.
10 - 16" 33-1/3 rpm cut at 96 lines per inch.
10 - 12" 33-1/3 rpm microgroove cut at 247 lines per inch.

Type 5. Thirty (30) duplicate variable groove spacing records from 88, 104, 112, 120, 247, 270, and 293 lines per inch recorded at a fixed frequency of 400 cps, with a stepwise increase from standard level to maximum permissible level.
10 - 12" 78 standard groove cut at 88, 104, 112 and 120 lines per inch both sides identical.
10 - 12" 33-1/3 standard groove cut at 88, 104, 112, 120 plus microgroove cut at 247, 270 and 293 lines per inch.
10 - 16" 33-1/3 standard groove cut at 88, 104, 112, 120 plus microgroove cut at 247, 270 and 293 lines per inch.

## PHASE II VINYL

The Vinyl records we have consist of 12" discs at 78 rpm; 12" discs at 33-1/3 microgroove; and 7" discs microgroove at 45 rpm. Therefore, I have limited this to include only these records. Since we have information on five different compounds that Vinyl pressings are made from, I suggest the following distribution.

Type 1. Blank discs. One Hundred (100)

10 12" discs and 10 7" (45 rpm) of Vinyl compound A
10 12" discs and 10 7" of Vinyl compound B
10 12" discs and 10 7" of Vinyl compound C
10 12" discs and 10 7" of Vinyl compound D
10 12" discs and 10 7" of Vinyl compound E

The 12" discs mentioned above will cover the 78 rpm discs as well as the 33-1/3 microgroove discs since they are made from the same material.

Type 2. Unmodulated grooves. One-hundred and fifty (150)

50 - 12" 78 rpm cut at 88, 104, 112, 120 lines per inch. (10 pressings of each vinyl compound).
50 - 12" 33-1/3 microgroove cut at 200, 240, 280 and 320 lines per inch (10 pressings of each vinyl compound).
50 - 7" 45 rpm cut at 180, 200, 240, and 280 lines per inch (10 pressings of each vinyl compound)

These discs to be cut both sides the same and spaced to cover the average playing time of the record.

Type 3. One-hundred and fifty (150) standard frequency test discs with bands recorded at fixed frequencies from the outside in of: 1kc, 2kc, 4kc, 7kc, 10kc, 12kc, 15kc, spiral, 15kc, 12kc, 10kc, 7kc, 4kc, 2kc, 1kc. There will be a voice announcement of frequency past and level indicated by DBM meter across the recording head. Each frequency band to be 30 sec. long including the announcement. Discs to be recorded at constant velocity on one side and standard NAB equalization on the reverse side. Each frequency will have a minimum level, intermediate level and highest practical level included in each frequency band.

50 - 12" 78 rpm cut at 96 lines per inch. (10 pressings of each vinyl compound).
50 - 12" 33-1/3 microgroove cut at 240 lines per inch (10 pressings of each vinyl compound).
50 - 7" 45 rpm microgroove cut at 200 lines per inch. (10 pressings of each vinyl compound).

Type 3X. One-hundred and fifty (150) discs for constant amplitude recording; test discs with bands recorded at fixed frequencies of 50cps, 100cps, 200cps, 300cps, 400cps, spiral, 400cps, 300cps, 200cps, 100cps, 50cps. There will be a voice announcement of frequency past and level indicated by DBM meter across the recording head. Each frequency will have a minimum level, intermediate level, and highest practical level included in each frequency band.

50 - 12" 78 rpm cut at 96 lines per inch.
(10 pressings of each vinyl compound).

50 - 12" 33-1/3 rpm microgroove cut at 240 lines per inch.
(10 pressings of each vinyl compound).

50 - 7" 45 rpm microgroove cut at 200 lines per inch.
(10 pressings of each vinyl compound).

Type 4. One-hundred and fifty (150) Sweep frequency test records varying from 50 cycles per second to 10 cks with NAB equalization to permit evaluation of cross-talk. One side to be standard reference level (zero DBM at 1000 cps.) the other to be recorded 10 DBM above this.

50 - 12" 78 rpm cut at 96 lines per inch.
(10 pressings of each vinyl compound).

50 - 12" 33-1/3 rpm microgroove cut at 240 lines per inch.
(10 pressings of each vinyl compound).

50 - 7" 45 rpm microgroove cut at 200 lines per inch.
(10 pressings of each vinyl compound).

Type 5. One-hundred and fifty (150) duplicate variable groove spacing records from 88 to 320 lines per inch recorded at a fixed frequency of 400 cycles, with a stepwise increase in sound level within each groove spacing from standard reference level to maximum permissible level. Recorded on both sides.

50 - 12" 78 rpm cut at 88, 104, 112, 120 lines per inch
(10 pressings of each vinyl compound).

50 - 12"33-1/3 rpm microgroove cut at 200, 240, 280, and 320 lines per inch. (10 pressings of each vinyl compound).

50 - 7" rpm microgroove cut at 180, 200, and 240 lines per inch. (10 pressings of each vinyl compound).